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*On the Application of the Science of Geology to the purposes of
Practical Navigation. By Alexander Nimmo, Civil Engineer,
M. R. I. A. &c.*

Read October 27, 1823.

IT is an old and perhaps a trite observation, that all the various branches of science are calculated to throw light upon each other ; and hence, that an extended acquaintance with the several departments of natural knowledge is the surest way to attain to eminence in the pursuit of any one. In a society like this, composed of persons of different pursuits, and whose ideas are directed to a variety of objects, it is perhaps one of the greatest advantages, that, in any new enquiry, we may be enabled to draw from stores of information that are beyond the reach of any individual mind.

Geology, it has been said, is one of the youngest of the sciences ; and, though much has been done, of late years, to place it on that sure footing of observation and induction, without which, we know, there can be no real progress in natural knowledge, it is yet not entirely freed from those hypothetical notions, of which the works of its earliest writers entirely consist.

The *modus operandi*, by which the existing strata of the earth were first produced, or at least arranged in their present order, is still the favorite speculation among writers on Geology ; and, from the great question, whether the immediate agent has been water or caloric, by the presence or removal of which the particles of minerals have been arranged in their present form, there have arisen two

great sects or schools of Geologists, by the active zeal of whose disciples most of our present knowledge has been obtained.

I have often regretted, that the partisans of these several doctrines, in their ardour to jump to a conclusion in favour of their peculiar principle, have frequently overlooked the assistance which their investigations might have derived from the other departments of Science. They have often ascribed effects to chemical agency, which the present state of our knowledge in that science does not warrant us to assume; and others to the mechanical operation of water, which the laws of hydraulics enable us positively to pronounce impossible. And, on the other hand, there seem to be effects producible from each of these causes, as well as from the atmospheric or meteoric phenomena and the actions of living beings, which are in general entirely overlooked.

Geology however, so far as it is founded on observation, is still a science; and, in the delineation and description of the strata of the land, it is daily extending its bounds and its utility.

I am now about to introduce an application of it to the notice of the Academy, which seems never yet to have attracted the attention of those most interested in the pursuit; but from which I confidently hope, when observations are multiplied, that much public advantage may hereafter be obtained.

I have been some time engaged in a survey of the coasts, harbours, and fishing grounds, round this kingdom, with a view to the improvement and extension of the Irish fisheries. In this investigation, it has become necessary to take numerous soundings of the neighbouring sea, as well to discover the habitat of the different kinds of fish, as to direct the seamen to avoid dangers in navigating our shores. This has led me to consider the subject of soundings generally: one which, to the best of my knowledge, has never yet

been reduced to any kind of scientific principles ; but is left entirely in the hands of the experienced though uneducated seaman. In these hands it is however of great importance ; as, in shallow seas and on coasting voyages, it supersedes entirely the scientific part of navigation.

Two particulars are ascertained by the use of the sounding lead : the depth of water and nature of the bottom. It is to the latter only I shall call the attention of the Society.

It is the opinion of many Geologists, that the bottom of the sea, being the receptacle of all the disintegrated particles of the land, must be an immense bed of alluvion, the parts of which, from the motion caused by tides or currents, must tend constantly towards the deeper portions of the ocean.

It is evident, that the finer and lighter particles, which expose a greater surface in proportion to their gravity, are likely to be carried farthest ; so that near the shore we may expect to find gravels or shingle ; farther out sand ; beyond that mud ; and finally ooze or vegetable remains. In the same manner as in the beds of rivers, in the upper country, where the descent and consequently the velocity is rapid, we have rocks and boulders ; succeeded as we approach the plains by gravel, sand ; then clay or mud ; and, lastly, as the waters become sluggish and stagnant, by weeds and mosses.

There can be no doubt, but, in heavy inshore winds, the waters which are propelled by the friction of the air on their surface towards the shore, must run off again by a subaqueous current known to seamen by the name of the "undertow," and that this is the chief cause of the abrasion of the shores. The velocity of this current will naturally diminish as it gets into deeper water ; but may be very considerable even at great depths, as the following instance will show.

In the year 1804, I made some experiments on Lough Ness in the north of Scotland, in company with my friend Simon Frazer, Esq. of Foyers ; to discover the temperature of the water at the bottom of that lake, and whether it had any impregnation of salt agreeable to the theory of Count Rumford. After dropping a vessel of half a gallon several times to the depth of 120 fathoms, we found the boat had gradually drifted a mile up the lake, though the day was rather calm, and what little wind there was was blowing downward. We could only account for this, by suposing a subequous eddy to be produced by the waters of the surface being blown towards the lower end and returning by the bottom.

Accordingly, on an examination of the bottom of the sea along the north eastern shores of Ireland, I found this order of arrangement to be nearly what occurs.

From Howth, within Lambay and Rockabill, we have patches of rough ground, stones, shingles, and clay, to the Skerries Isles ; another patch of this kind is found north of Clogher head ; one north of Dunany extending to Cooley point, the Helly hunter rock off the coast of Mourne, &c. Outside of these, we have a zone of clean ground and sandy bottom from the Wicklow banks by Howth head, outside of Lambay to St. John's point, and thence to the Copeland. Such ground is fit for trawling on, and therefore its limits are well ascertained.

Beyond the sand, we have mud and ooze in the deep water until we approach the shores of the Isle of Man, where the sand and then rough ground again returns. The mud ground cannot be fished by the trawl : it is the resort of the cod and ling, which are taken by the hook and line, so that its extent is pretty well known to the fishermen. This mud ground however does not occupy the deep water generally ; but is confined to particular places.

On the hypothesis that the bottom of the sea is a great bed of al-

lution, produced by the action of currents on its own surface or on the neighbouring land, we may readily explain the existence of these mud grounds in the Irish sea by the motion of the tides ; for the finer matter will be naturally deposited in those places where there is comparatively still water.

The north and south tides on the east coast of Ireland meet off St. John's point, and the current is slackened for a considerable space ere it reach that. Hence we have little or no current of tide between Lambay and the Isle of Man ; and this is precisely the position of the great bed of mud.

In like manner another extent of mud ground occurs in the wake, as seamen call it, of the Isle of Man, between that isle and the coast of Lancashire and Cumberland ; for the streams, setting up St. George's channel and in by the north channel, meet and regurgitate on this coast, producing high tides and still water, and a consequent deposition in the offing. This mud ground extends from off the mouth of the Ribble northward, and to the mid-channel between St. Bee's head in Cumberland and the Isle of Man.

A third but smaller portion lies in Carnarvon Bay, in the wake of Brachypult point, where also there is little stream of tide.

Another in the mouth of Clyde in the wake of Cantire, and many smaller in sheltered places.

As it is evident therefore, that these are alluvial depositions, it does not seem too much to admit, that the adjacent portions or zones of sand are in all probability the rougher particles of the strata, not admitting of being transported so far, or whose finer particles are swept off into the still water.

It would appear, that the current of tide which sweeps these particles before it, so far from carrying them out into the deep water of the ocean, tends rather to regorge them against the shores : the tidal water, after the reflection from the coast, naturally returning

by the surface, occasions less action against the bottom during the ebb. But, as we pass off towards the ocean, we are presented with phenomena of a different kind.

To the south of the bay of Dublin, along our shores, are the remarkable banks called the Irish grounds. They have never yet been sufficiently explored; and I was called off to the west of Ireland last year, when about to begin that survey. I am however strongly inclined to think these banks will be found, not merely accumulations of sand, but to be in fact owing to the existence of ridges of rock or other solid matter in that situation; the more especially as the rough bottom extends from thence all the way over to Carnarvonshire.

To the southward of the parallel of Wicklow, and outside of the banks, there is, in the middle of the channel, a remarkable deposition of shells. It extends at least as far as the parallel of Tuskar, where it is again succeeded by sand, which composes most part of the flat called the Nymph bank.

This extensive shelly bed necessarily implies a peculiar supply of calcareous matter; and it is particularly remarkable, that the country on either side cannot have produced it. There are no rivers of any consequence; and the shores, on either side, are composed entirely of slate and granite. Here then is a substance composing the bottom of the sea, to a great extent, which is evidently not the result of alluvion.

A similar extensive shelly bed occupies the centre of the wide part of the sea between Lancashire, Wales, and the Isle of Man. That portion of the sea however has limestone shores in Furness, Lancashire, Denbighshire, and Anglesea; and therefore the existence of calcareous matter, in the bottom of the sea, may not be so remarkable.

Most Geologists are agreed, that the abundance of organic remains in the limestone rocks show them to have been, at some former period, the residence of animals. Nay some have gone so far as to suppose, that these rocks are entirely composed of the remains of the animals of a former race, consolidated together by the effect of subsequent revolutions of the globe. In either way, the position of the great shell beds before mentioned bears a singular analogy to the situation of the limestone strata, which covers so large an extent of Ireland ; and it might perhaps be possible to discover, by a careful examination of the shelly remains, whether they are portions of the petrifications from a limestone rock abraded by the action of the sea, or the exuviae of animals now in existence. In the mean time, it is proper to observe, that no other so remarkable a bed of shelly matter occurs elsewhere in the Irish sea, or until you get beyond the northern straits into the Atlantic ; nor do I know of any so remarkable in the north sea, though the nature of its bottom appears to have been carefully investigated by pilots.

In the British channel however, there is another extensive tract of this nature occupying the centre of the space between England and France, and for many miles to the westward while you keep south of Scilly ; but, to the north of Scilly, the bottom is of an entirely different nature.

Nothing is more interesting to Navigators, on their way home from the Atlantic to our coasts, than the means of distinctly ascertaining their position on approaching the land. In thick weather, when astronomical observations are not to be had, and when, from the influence of unknown currents or the like, the reckoning may be justly suspected, it is of the utmost consequence to keep the ship in the fair way of the channel.

Experienced pilots allege, that this may be known by the nature

of the soundings, and have formed tables of these for the use of navigators; but their modes of description are so vague, that it is difficult to reconcile them, and hence an opinion has arisen among many, that this kind of knowledge is not to be depended on.

The portion of the ocean adjacent to the mouth of the channel, being so much traversed by the maritime nations, has been rather minutely explored; and the bank of soundings, or that space wherein the sea is less than 100 fathoms in depth, and which is nearly confined within a line drawn from Bourdeaux to the west of Ireland, has been delineated both by French and English Hydrographers.

This line, or the edge of the bank, is about 200 miles to the west of the Land's end of Cornwall; for the last 150 miles, the ground is almost flat; but, beyond that line, the inclination of the bottom rapidly changes, and the depth suddenly increases to 200 fathoms and upwards. Round the bottom of the bay of Biscay, this depth is found within a few miles of the shore.

On so extensive and level a plain, it would be unreasonable to expect the bottom to be entirely composed of alluvion from distant lands. The action of the ebbing and flowing tide must nearly be the same each way; and, although it may have the effect of grinding or wearing down the upper surface of the strata into small fragments or fine sand, yet it cannot transport them far from the place where they are produced.

In fact, we find that the pilots, although their notes are inserted only in detached places, ascribe a uniformity of character to considerable portions of the bottom; showing distinctly, that, *like the soils on the dry land, this character must derive its origin from the nature of the subjacent rock, by the disintegration of which these soils are formed.*

Unfortunately the pilot has never yet been taught to consider the chemical or mineralogical character of the substances, which he brings from the bottom of the sea, so that it is not easy to conjecture what is meant by the descriptions he gives ; but, with the last idea in view, I think much light may be thrown on the subject, and hereafter we may hope for more distinct information and a better nomenclature.

If what I am now about to state be confirmed by future observation, the position of the *Navigator* a hundred miles at sea may be as certainly ascertained by sounding as if he was within sight of land.

It is agreed on all hands, that, if there be any thing tolerably certain in Geological science, it is, that the component rocks of the globe follow a certain order of position with respect to each other : that, for example, the chrystallized granitic rocks are the lowest, followed by the slaty, whether micaceous or argillaceous ; that these are covered by the conglomerate sandstone beds, this again by the limestone, that by sandstone and coal, and the coal measures are again covered by other horizontal strata of various kinds, viz. red marl, oolites, chalk, &c. of which, though they constitute the chief strata in the east of England and in France, we have few examples in this country, and therefore they need not be here particularized.

Now observe, that the strata of the west of France and England are primary, viz. granite and slate ; those of Wales and the south of Ireland, slate, conglomerate, and coal ; and that, for a great way up the channel, we need expect to find nothing higher in the series of strata.

When we look at the western edge of the bank of soundings, we find it described as fine white sand, *i. e.* quartz ; white sand with black specks, *i. e.* quartz with mica ; and, along the south edge,

gray or granite sand, extending all the way into the shores of Brittany, which are also granite.

The *Sole-bank*, which lies about five leagues within the edge of the soundings, about as large as Cornwall, and 180 feet over the general level is mostly fine white sand and black specks, evidently a fine grained granite country. To the east of this, a large tract lies on the south side of the fair way distinguished by coarse red sand, stones, and gravel. This is just what we might expect from the disintegration of the red conglomerate sandstone, which covers the primary rocks, and is succeeded by the limestone; and accordingly, immediately when we pass this red stony tract, we enter on the great shell bed, which, although not noticed particularly to the westward of the red tract, continues all the way up the middle of the channel, until we fall in with the chalk country of the south of England.

The shelly tract spreads away to either side of the red sandstone, westward, in two narrow streaks; and, by keeping within the northernmost of these, we avoid falling into the Irish channel. And, to the north of this, is a tract of gray sand with black specks, which may be traced all the way from the Solebank aforesaid into the isles of Scilly; shewing evidently its connection with the granites and mica slate of those isles and Cornwall.

To the south of this, between the shell bed and the Scilly islands, is an extensive tract of brown sand. I can only suppose a disintegrated graywacké, or brown slate rock, or killas, as it would be named in Cornwall; especially as the same character obtains to the south of the western part of Ireland, where it seems an extension of the brown slate country of Cork and Kerry.

When, so far in as the line from Cork to Ushant, we have about sixty fathoms water, the line however which marks that depth in-

dents into the two channels, and passes a good way to the west of Scilly. The decision as to which channel we are in should therefore be made before we are in that depth ; as, if we have got too far to the northward, and are making to the English channel, we will find the current described by Major Rennel, and the prevalent southerly winds, greatly to obstruct our progress.

Sixty miles west of Scilly, is Jones's bank forty fathoms and ooze. This is the highest portion of a great ooze bed, which particularly distinguishes the St. George's channel. It extends from the meridian of Scilly westward to near the edge of the bank of Soundings. This soft ground does not stick to the bottom of the lead when armed with tallow ; butter is therefore used for that purpose. As we have traced the other soundings to similar rocks on the shores, so this great ooze bed, if an original formation, may perhaps be considered as a continuation of that great field of coal, which, beginning at Newcastle, passes through England to Bristol and South Wales. I think I have I found the same deposition in other similar situations.

Nearer the Irish shore, we have again the graywacké, or brown slate sand, occupying all the bottom to the coast of Munster, as might be expected. That coast, from Waterford to the Blaskets, is one uninterrupted tract of brown slate. The Nymph bank is chiefly conglomerate, and from thence towards the Bristol channel I have no positive information of the nature of the soundings.

It appears to be therefore possible, on rational principles, to delineate masses of the different soils of the bottom of the sea, as has been done for those of the land ; and, by instructing the pilot more carefully to ascertain the distinctions between the various kinds of sand or other matter which he may bring up from the bottom, so as more readily to refer to the corresponding part of his chart, it is

evident, that a great additional precision will be afforded to this mode of discovering his place, when astronomical observations are not to be had and his reckoning is doubtful.

I have annexed to this paper a reduced chart of the bank of Soundings, on which the various descriptions of bottom above noticed are distinguished by colours, as far as they can be ascertained from our present charts; and also a series of lines of equal sounding, at every ten fathoms in succession, from fifty to one hundred fathoms.

In this way, a species of meshwork subdivision of the bank is effected, similar to what we obtain by the lines of latitude and longitude, or those of equal variation of the compass.

The chart is necessarily very imperfect, but it illustrates what I have in view; and, from the well known zeal and talent of our navigators, we may look forward confidently to its future improvement.

I have pursued the same idea over charts of other portions of the ocean, which I may make the subject of a future communication.